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Tropical forests are the largest terrestrial component of the global carbon budget. However, agreement is lacking on their net contribution to the terrestrial carbon balance over the past two decades.
The existing aboveground carbon (AGC) estimates are based on the measurements of aboveground biomass (AGB). In situ AGB measurement is a laborious, and expensive approach at large scales. Forest inventories, as a non-destructive way, are unavailable in many developing countries in tropical regions with large areas of natural forests, which limits the estimation of tropical AGB.
Remote sensing offers a relatively low-cost, rapid, and repeatable method for monitoring the spatial and temporal dynamics in AGC. Three types of remote sensing sensors are used to estimate AGC: optical, LiDAR and microwave sensors. The main shortcomings of optical imagery are the saturation of the observed signal for large values of forest AGC, and the effects of cloud cover and high aerosol optical depth (AOD) leading to high uncertainties in the estimation of AGB over the tropics. Synthetic Aperture Radar (SAR) observations have similar problems of saturation in the backscatter signals in dense forest regions at L-band. Conversely, LiDAR is not limited by the signal saturation for the AGB estimation, but LiDAR failed to estimate the dynamics in tropical ABC in the recent decade because the Geoscience Laser Altimeter System (GLAS), as the only space-borne LiDAR sensor available over the past years, scanned the globe only from 2003 to 2010.
Passive microwave remote sensing can detect changes in canopy structure, biomass, and soil and vegetation water content and can thus provide an alternative method for monitoring ABC independently of many constraints of optical-IR and thermal remote sensing. Due to the longer wavelengths of passive microwave systems, the microwave remote sensing observations have less sensitivity to atmospheric and cloud contamination effects and can sense the microwave emission from deeper layers within the canopy (and therefore saturates at a higher biomass level than NDVI)
The newly developed SMOS-IC VOD product (L-VOD) was retrieved from the low-frequency L-band (1.4 GHz) passive microwave observations from the Soil Moisture and Ocean salinity (SMOS) satellite. SMOS, launched in November 2009, was the first ever space-borne satellite operating at L-band. The low-frequency observations of SMOS enables the L-VOD product to be less sensitive to saturation effects at relatively high biomass levels, and to be sensitive to variations of AGC at relatively higher biomass levels, than VOD estimated from high frequency (> 6 GHz) observations. The SMOS-IC L-VOD product has the great advantage to be as independent as possible from auxiliary data.
Tropical AGC changes during 2010-2017 were estimated by LVOD, indicating that the tropical region acted as a neutral carbon balance of tropical biomes of +0.11 Pg C yr-1 during 2010-2017, but varied strongly inter-annually, with a large increase in AGC during the very wet 2011 La Niña year and a large decrease in the extreme dry and warm 2015-2016 El Niño episode.